Digital Imaging for TEM - Part III
Characterizing Digital Images

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Last months issue of this publication contained the second article article in this series on digital imaging for TEM - and listed factors that may be stimulating the recent interest in digital imaging for TEM. Most of the factors are concerned with issues of functionality. A digital imaging system can enhance TEM operation, image storage, image processing and communication. Significantly, the surge in interest was not linked to claims that digital images have better detail than images captured using sheet film. This is a pivotal issue for some microscopists. Nevertheless, my experience has been that many microscopists, even skeptical microscopists, are surprised at the quality of output from a modern digital imaging system when using a high quality output device to produce hard copy images.

This article discusses the image detail available using a typical modern digital imaging system and compares this with comparative figures for sheet film.

Image detail is considered in terms of an image's pixel population and gray scale resolution (figure 1). The product of these two factors can be a useful measure of the detail in an image.

Digital Imaging Systems for TEM

An image's pixel population is the number of pixels that are used to form an image. If an image is formed using more pixels, it should display more detail than an image formed with fewer pixels.

A typical modern digital imaging system for TEM produces images with a pixel population of about 1,000,000 pixels. These are usually arranged in a square (or nearly square) array. Manufacturers will speak of systems offering "1024 by 1024 pixels" or "1000 line cameras".

This does not imply that digital imaging technology cannot produce images with greater pixel populations. Many manufacturers can produce systems offering 4 million pixels or higher. Nevertheless, the ultimate limitations for most microscopists are system cost and complexity. Both increase dramatically.

An image's gray scale resolution indicates the number of possible shades of gray (from saturated white to saturated black) that can be ascribed to any pixel within an image. An image with low gray scale resolution can be expected to show little detail. An image with high gray scale resolution can be expected to show more detail.

A typical modern digital imaging system for TEM produces images with a gray scale resolution of around 256 gray levels. Manufacturers may speak of images being "8 bits deep". The term "8 bits" corresponds to 2^8, which is 2x2x2x2x2x2x2x2, which equals 256.

Here again, manufacturers can produce imaging systems with gray scales of 1024 (10 bits) or even 65536 (16 bits) gray levels. As with the issue of pixel population, cost and system complexity become limiting factors for most microscopists.

The product of an image's pixel population and gray scale resolution can be a good indicator of image detail. A "1024 by 1024 by 8 bits deep" image can be expected to show more detail than a "512 by 512 by 6 bits deep" image of the same structure. Nevertheless, common sense indicates that an image with a high pixel population but low gray scale resolution might be considered less detailed than an image with a more modest pixel population but a higher gray scale resolution.

A Comparison with Sheet Film

If we try to develop similar characteristics for sheet film we have to include some interpretation. In the type of film used for TEM applications, the size distribution of the photosensitive crystals are said to range from about 10 to 30 μm in diameter. If we assume they cover the entire surface of the film we can calculate that a 4" by 3" piece of sheet film has a pixel population of between 9 million and 81 million pixels.

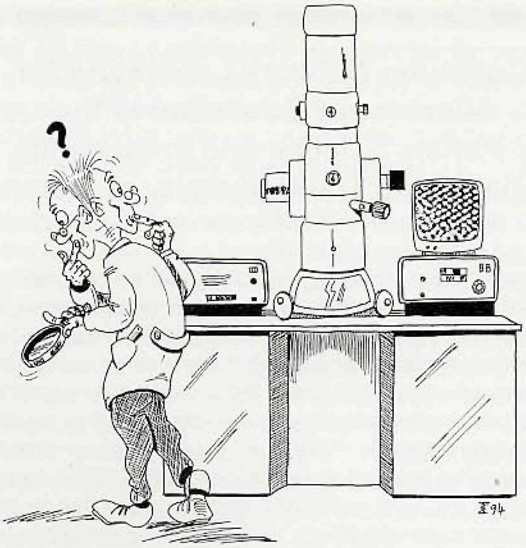
The response of sheet film to light is not digital but rather it is an analog process and, as such, one can argue that sheet film has an infinite gray scale resolution!

Consequences

If we compare the pixel populations and gray scale resolutions of a typical modern digital imaging system for TEM with equivalent figures for sheet film, it is clear that the parameters are very out of line. Sheet film has a very impressive specification. This will confirm the conclusions of many digital imaging skeptics.

Perhaps more significantly, if we compare the pixel populations and gray scale resolution for what we might call an extremely advanced digital imaging system with equivalent figures for sheet film, the situation is not much better. Clearly, if a microscopist is waiting for the basic specification of a digital imaging system to "beat" sheet film, he or she need not roam the MSA Equipment Exhibit for a good few years to come!

This raises the question of why so many microscopists are surprised by the apparent good quality of hard copy from a modern digital imaging system. Well, this may be due to the fact that we humans are a "weak link" in the information system we use for TEM analysis. Put simply, it matters little whether you have an imaging system that is somewhat detailed or extremely detailed if you, as the observer, cannot discern the added detail. With this in mind, next month's article will consider how the imaging quality of a typical modern digital imaging system stacks up against the imaging quality of a typical modern microscopist. ■



Why has not Man a microscopic eye?
For this plain reason, Man is not a Fly.
Say what the use, were finer optics giv'n,
T'inspect a mite, not comprehend the heav'n.
Alexander Pope 1733

Faith is a fine invention
When gentlemen can see,
But microscopes are prudent
In an emergency.
Emily Dickinson 1860